



***DEATH ON THE STEPPES –
The Nedelin Rocket Disaster***

**Leadership ViTS Meeting
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The Mishap

- **Where:** Baikonur Cosmodrome (also known as Tyuratam), Soviet Union
- **When:** October 24th, 1960
- **What Happened:** Fuel valves in the second stage of the Soviet's R-16 ICBM prototype were inadvertently opened, and hypergolic propellants mixed and burned into the first stage causing a massive explosion at the launch pad
- The number of personnel and visitors in close proximity to the launch pad exceeded safe limits given that technicians were performing repairs on a fully-fueled rocket
- At least 74 people died from the fireball and toxic gases, and approximately 50 more died later from the injuries received that day
- Marshal of Artillery Mitrofan Nedelin, who was personally in charge of the R-16 program, was at the launch pad and one of the 74 killed





What Went Wrong?

The incident was kept a secret for decades. Even long after the end of the Cold War, much of the history of the Soviet missile program remains shrouded in mystery. However, sources indicate what likely happened:*

- **Proximate Cause:** Poor design of the control system allowed ignition of the second stage during pre-launch processing. A failed “block” in the electrical system did not prevent a spurious command signal from opening the second stage valves and allowing the hypergolic fuel and oxidizer to mix and ignite
- **Secondary Causes:** Repairs to an earlier problem with leaking fuel in the first stage, and subsequent tests of the repairs that were performed quickly and sometimes simultaneously, left components in varying stages of launch readiness



The R-16 had been leaking propellant.

* Siddiqu, Asif. *Mourning Star*, Quest Magazine, Winter 1994
Zak, Anatoly. *Rockets: R-16 family: Nedelin Disaster*, RussianSpaceWeb.com, www.russianspaceweb.com
Dr. Yoon, Joseph, *Nedelin Disaster*, AerospaceWebOrg, www.aerospaceweb.org



Underlying Issues

➤ Political Pressure

- Soviet Union and USA in arms race for ICBM superiority

➤ Schedule Pressure

- Rushed development cycle
- Marshal Nedelin under pressure from Khrushchev for an on-time, successful R-16 launch

Soviet armed forces producing rockets like "sausages from a machine"

*Khrushchev in a speech to the United Nations
days before launch*

➤ Safety Rules Non-existent or Not Followed

- Launch Range and Safety Officials overruled by Nedelin
 - Approximately 150 unauthorized personnel too close to launch pad during fueling & testing
- Repair work (e.g., soldering) performed on a fully-fueled rocket
 - Requests to drain the rocket first were refused by Nedelin:

There would be no time for such things in a nuclear war

➤ Rushed Design Verification Flight Test

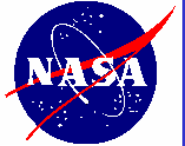
- Multiple technical problems (e.g., pyrotechnic miss-fires, fuel leaks) as launch approached
- Poor operational planning for an "on-pad" abort
- Technicians were worked around the clock to repair problems and perform tests

➤ Poor Documentation

- Only limited documentation and rough diagrams, some not available at the launch pad, for repairs and testing

➤ Poor Design

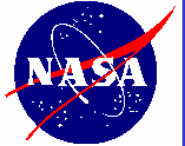
- Inadequate fail-safes built into the vehicle
- No established provision for safely detanking hazardous propellants



What Does This Have to Do With NASA?

General Thoughts:

- **Remain vigilant in granting access to hazardous areas within space launch and processing facilities.**
- **Ensure thorough systems safety engineering as an integral part of the design process and throughout the program life-cycle**
- **Ensure that spacecraft and launch vehicle designs enable safe detanking activities on the launch pad**
- **Promote ways to get people reading, discussing, and thinking about complex system failures and lessons learned**
 - The challenge is packaging the message and motivating people to use the “lessons learned” available across the Agency
 - Internalization of these lessons must guide the design, development, and operation of complex systems



The Safety Message

- **Even 40+ years after the Nedelin disaster, system failures remain poised to strike whenever key causal factors interact, compound, or align**
 - schedule / budget / political pressures
 - and/or less than adequate
 - design, workmanship, maintenance
 - procedures, process discipline
 - compliance verification
 - communication

***Don't be seduced by success –
the price of safety is constant vigilance.***



Backup



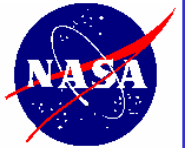
Accident Background

- **Place: Baikonur Cosmodrome**
- **Accident Date: October 21st-24th, 1960**

Accident Background:

Design deficiencies of early Soviet intercontinental ballistic missiles in the late 1950s arms race with the USA led the Soviet leadership to initiate the development of a new type of missile, designated the R-16.

Of such importance to Soviet leadership was the R-16 that the head of the Soviet ballistic missile force, Marshal Mitrofan Nedelin, was placed in charge. Rushing to test launch the R-16 as a celebratory gift to Khrushchev for the anniversary of the Bolshevik revolution, design, development, and flight-development testing schedules were dangerously compressed.



The Accident- What Happened?

October 21st – 23rd

➤ **The R-16 was moved to the pad and after the initial safety checks had been successfully completed, the rocket was fueled.**

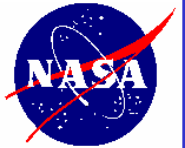
- **Rules Ignored** - Due to the failure to follow (or lack of sufficient safety procedures), both Marshal Nedelin and rocket designer Yangel, along with about 150 other non-essential personnel, remained on the launch pad during fueling and testing. Nedelin reportedly set up a chair to observe and direct operations.
- **Technical problems** - As launch time approached, the membranes that prevented propellants from getting into the propellant lines were opened in preparation for launch. Following this, a set of explosive pyrotechnic devices on the valves of one of the first-stage engines went off, apparently spontaneously. One or both of these resulted in a leak of propellants, though accounts differ on the leak rate.



The Accident- What Happened?

October 21st – 23rd (Continued)

- **The R-16 had suffered a technical problem resulting in a propellant leak and repairs were needed.**
 - **Unnecessary Risks taken** - Repairs to the replace the blown pyrotechnics on the valves in the automatic control system were made. According to some reports, requests were made to drain the propellant prior to repairs, though there was no established procedure to do so, but Nedelin refused saying that there would be no time for such things in nuclear war.
 - It was possible that once fueled, components would not be able to be used again if the rocket was drained due to the caustic nature of the propellants.
 - Lines were tightened and the leak rate was seemingly deemed acceptable for continuing.
 - **Stressing Environment** - The launch was pushed back to the next day as technicians worked to complete repairs and testing. It appears that many common sense safety procedures were violated, such as soldering joints in the propellant lines on a fully-fueled rocket.



The Accident- What Happened?

October 24th

➤ **Rushed repairs and testing to the propellant system continue.**

- **Political pressures** - A group of high-government officials arrived to view the launch at a stand set up only several hundred meters from the pad. Nedelin reportedly had at least two conversations with an impatient Khrushchev over the lack of progress. Khrushchev had made a speech days earlier to the United Nations about the might of Soviet armed forces and claimed that rockets were being produced like “sausages from a machine.”
- **Poor leadership** - After another 30-minute delay, Nedelin insisted on returning to the pad and sitting just a few meters away to oversee things. As the day slipped away and under pressure from superiors, frantic technicians began running tests quickly and simultaneously. According to some reports, the only schematic of the rocket’s electrical system (a rough schematic diagram) was not available as the engineer who had it was not allowed on the pad.



The Accident- What Happened?

October 24th (Continued)

➤ The stage for disaster had been set.

- **Design problem** - During the hurried, launch pad testing, the automatic control system for the fuel valves had been cycled out of launch position. A technician sent a command to reset it to its launch condition, but this sent a spurious signal to open the propellant line valves of the second-stage engines. A “block” in the electrical system failed to prevent the signal from reaching operational portions of the rocket during testing.
- **Tragedy** - The hypergolic (self-igniting) propellants of the second stage mixed, lit in the engine and quickly burned through the top of the first stage, which then exploded. The expanding ball of 3000° F fire and toxic gases instantly killed many personnel, covered others in burning propellant and suffocated some with acidic fumes. At least 74 people died that day, including Nedelin and approximately 50 more died later from the injuries received that day.